Effects of Local and Regional Circulation Patterns on Ozone Concentrations in Phoenix

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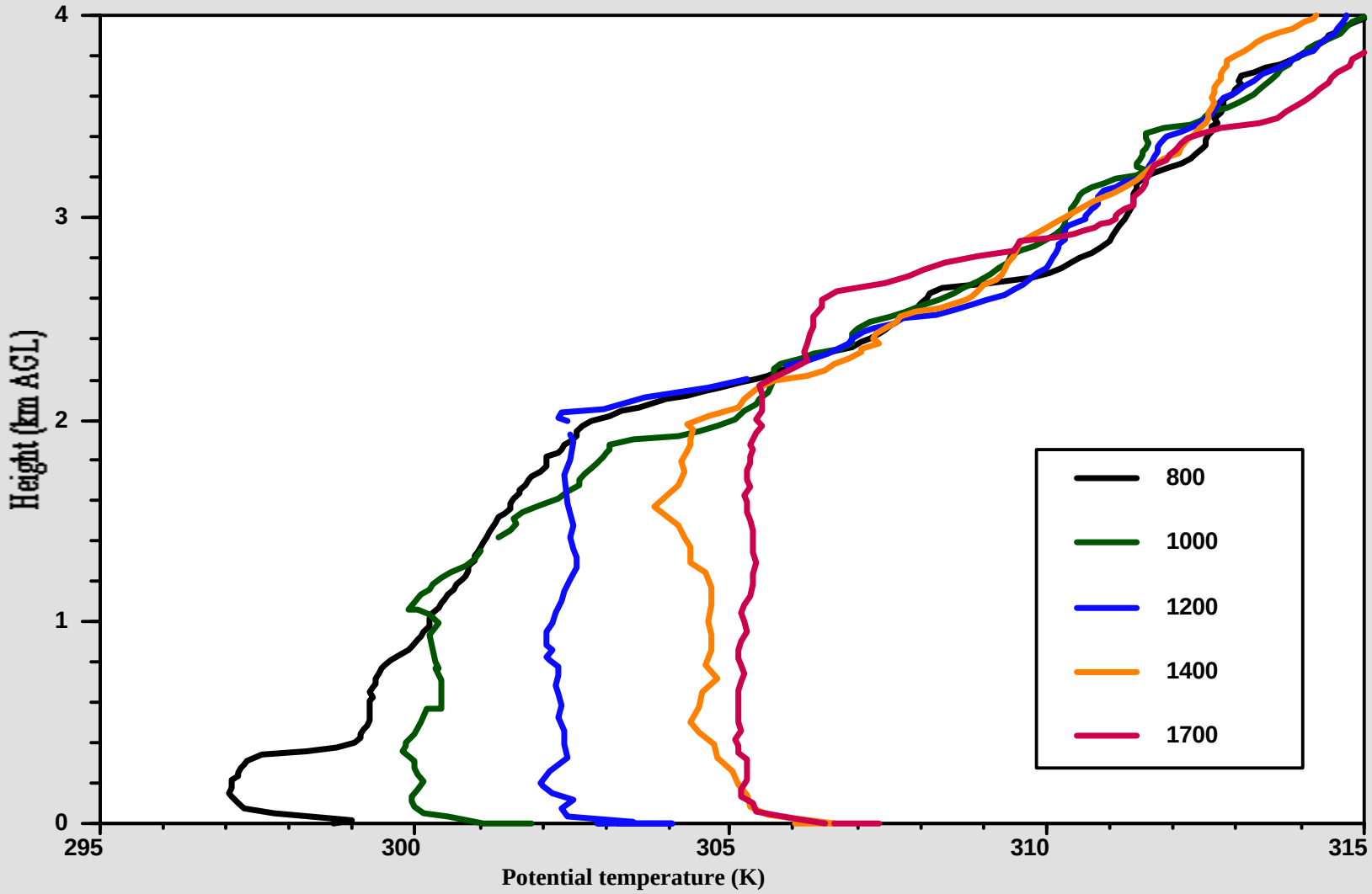
Measurements of vertical profiles of wind velocities and temperatures were made during a 4-week period in Phoenix in May and June of 1999 to provide meteorological information needed for an understanding of ozone data obtained from the G-1 airplane and from surface stations.

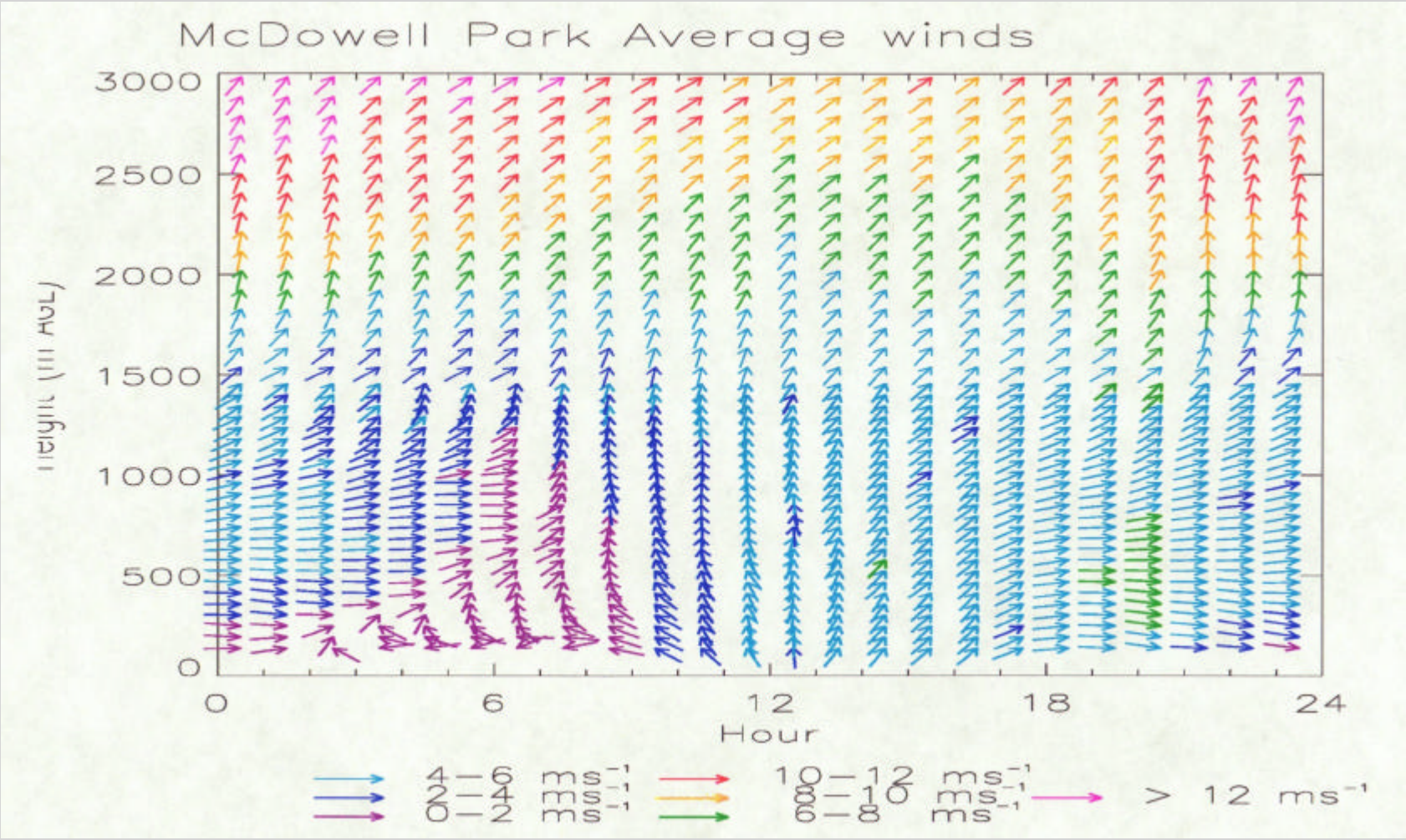
Radar wind profilers were located at sites P, M, and F, and provided continuous hourly values of wind speeds and directions to heights > 3000 m.

Radiosondes were launched from sites P and M at 0800, 1000, 12000, 1400, and 1700 LST on all days the G-1 flew and (at least) at 1700 LST on days prior to flights.

Profiler data showed clear evidence of thermal influences from the nearby mountains over depths greater than 1500 m. Deep (> 2500 m) mixed layers and winds of 4-6 m s^{-1} in the upper portions of the mixed layers ensured good ventilation of the valley on most days.



Potential temperature profiles measured over downtown Phoenix on 26 May 1998 showing growth of mixed layer to depth > 2000 m.

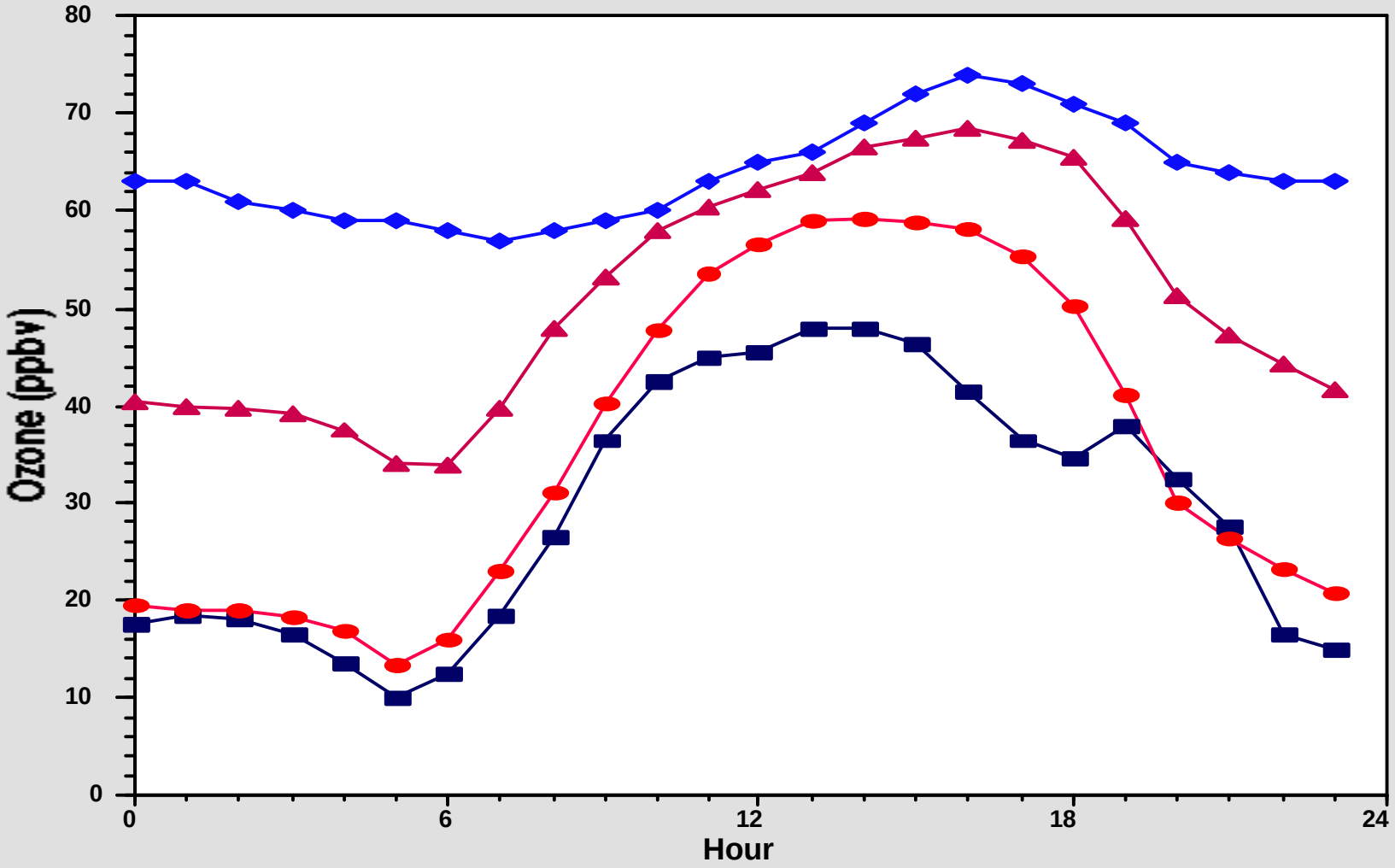


Average diurnal variation of winds at McDowell Park (site M) during undisturbed weather conditions, 18 May - 9 June 1998.

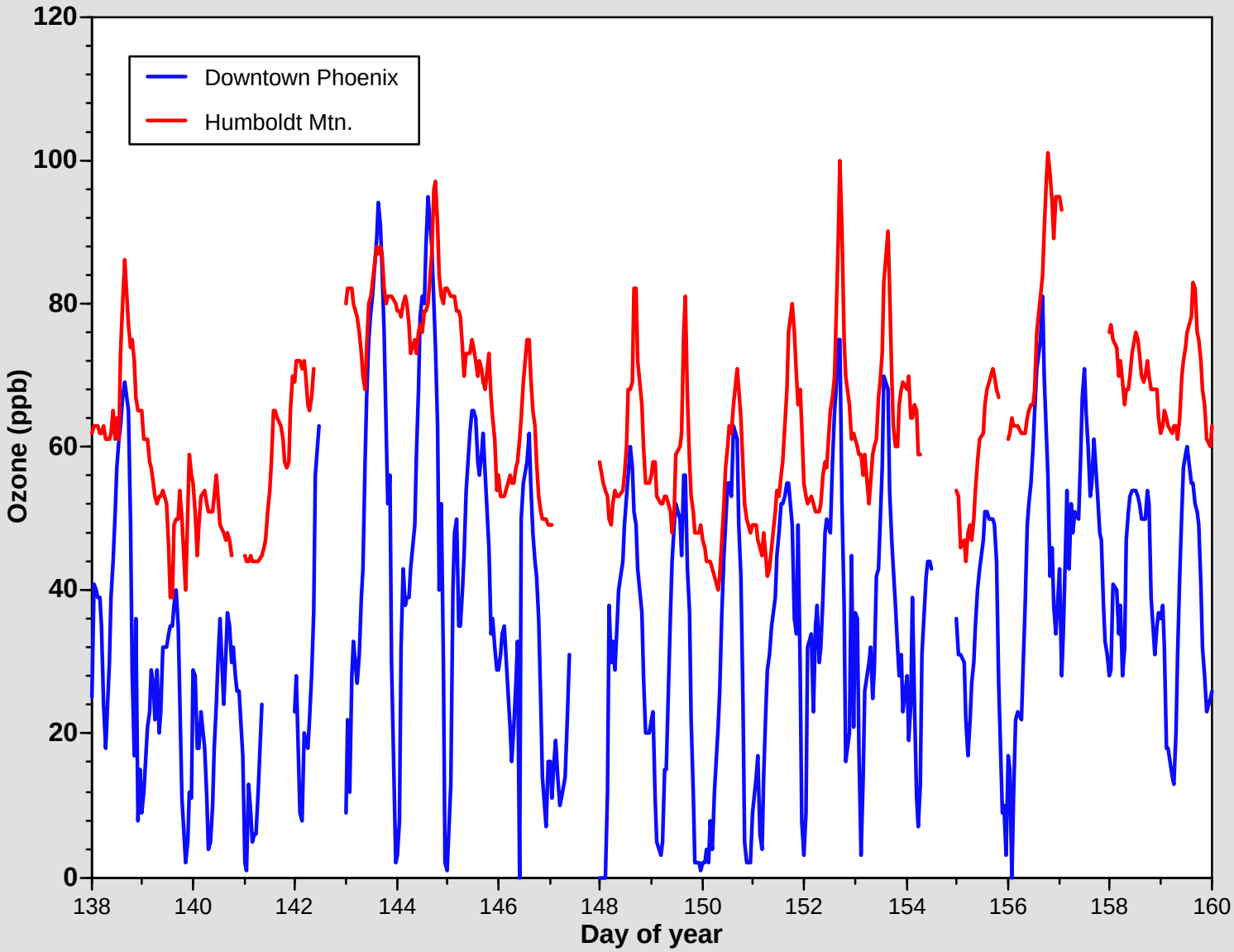
The average diurnal variations of ozone at sampling stations distributed over the valley and the mountains showed a tendency to cluster into groups. Ozone peaks were larger and occurred later in the day as one moved from upwind locations (southwest) to sites nearer the city center and then on to the higher terrain toward the east and north.

Nighttime ozone values approached zero near downtown Phoenix but averaged over 60 ppb at the Humboldt Mountain site during the experiment. A comparison of the ozone time series at Humboldt Mountain and at a site in downtown Phoenix shows similar diurnal and long term trends. Peak values measured aloft by the G-1 airplane were consistent with these trends.

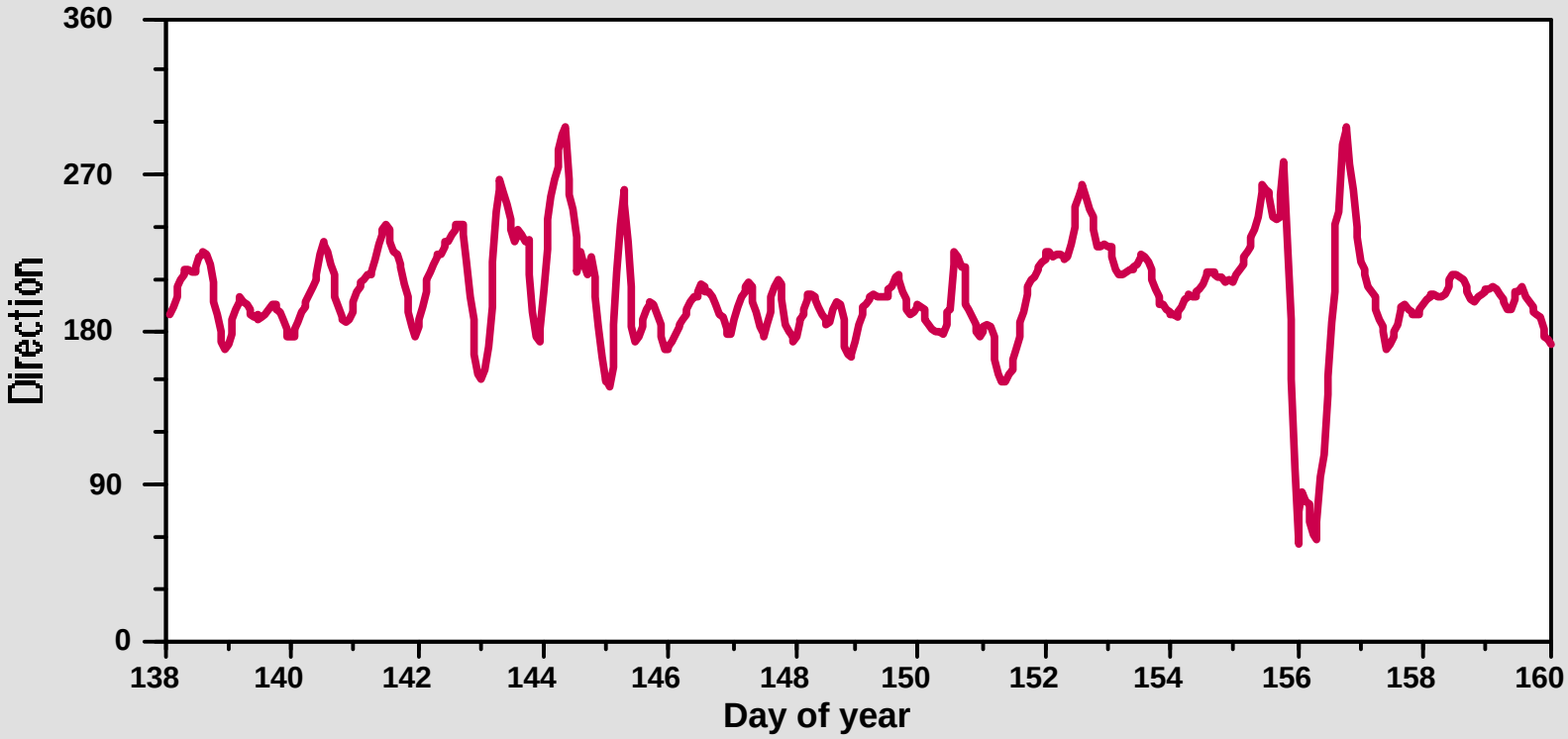
The largest background values of ozone at the Humboldt Mountain site tended to occur when the winds aloft shifted to a more westerly direction; background values were lower for more southerly directions. This dependence suggests the possible importance of long-range transport on local ozone concentrations.



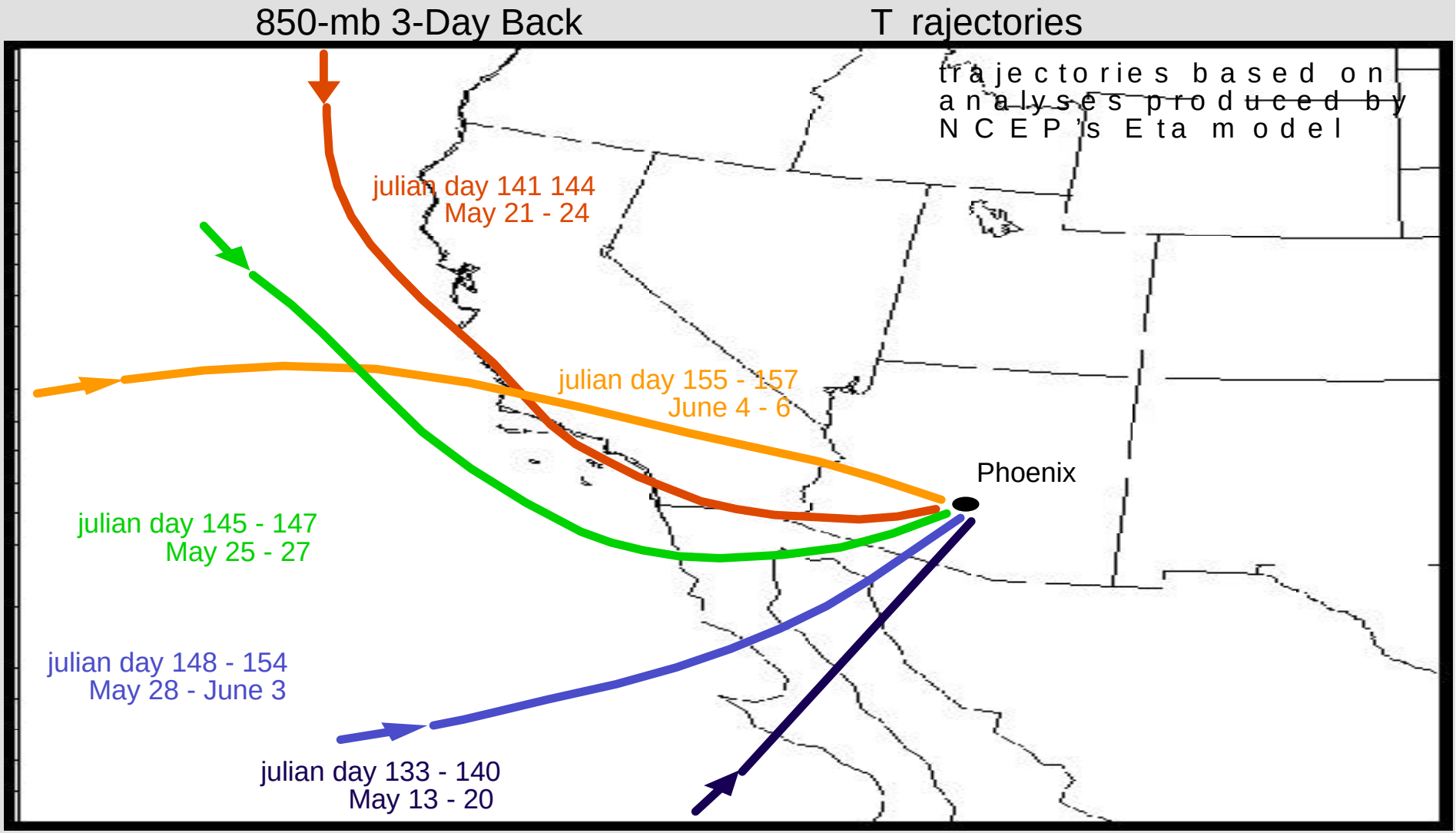
Average diurnal variations of ozone concentrations on undisturbed days at the sites shown on the topographic map above, 18 May - 9 June 1998



Diurnal variations of ozone concentrations at Humboldt Mountain and at a site in downtown Phoenix



Wind directions at approximately 2000 m AGL above site M, showing diurnal variations and longer term trends. Periods with more westerly winds generally correspond to occurrences of higher ozone values at Humboldt Mountain site.



3-day 850-mb back trajectories derived from NCEP Eta model

Summary

1. Local flows generated by the heating of adjacent elevated terrain strongly affected the temporal and spatial evolution of ozone concentrations in the Phoenix area.

2. Deep mixed layers, coupled with light to moderate winds, generally precluded multi-day pollution buildup from local sources.

3. Periods of higher ozone concentrations correlated well with shifts in ambient wind directions and periods of lighter winds. Trajectory analyses suggest that regional transport of polluted air from external sources is a major factor contributing to elevated ozone concentrations near Phoenix.

4. More detailed trajectory analyses will be carried out with a nested mesoscale model to examine regional scale influences.